

## RUBBERY POLYMER WITH IMPROVED PROPERTIES

### Background of the Invention

Automotive instrument panels and door panels are  
5 typically composites which are made of a rigid backing  
which supports a semi-rigid urethane foam with the semi-  
rigid urethane foam being covered with a skin compound.  
Such skin compounds are typically blends of polyvinyl  
chloride (PVC) with a nitrile rubber (NBR).

10 The nitrile rubber is included in such blends as a  
permanent modifier for the PVC which provides it with a  
higher degree of flexibility.

The automotive industry is currently moving toward more  
aerodynamic body designs which typically include larger  
15 glass areas. Such design changes have significantly  
increased the heat and ultraviolet light aging requirements  
of automotive interiors. This has in turn significantly  
increased the demands put upon the polymers which are  
utilized as skins in automotive interior panels.

20 Heat and light stabilizers can be employed to improve  
the heat and ultraviolet light aging characteristics of  
conventional PVC/NBR blends which are utilized as skins for  
automotive interior panels.

However, the degree to which the aging characteristics  
25 of such blends can be improved by the addition of additives  
is limited. In fact, there is a demand for performance  
characteristics in such applications which theretofore has  
not been realized by the utilization of heat and light  
stabilizers. For instance, it would be highly desirable for  
30 the skins used in automotive panels to resist discoloration  
and cracking under conditions of high heat and intense  
ultraviolet light throughout the life of the vehicle.

NBR/PVC blends offer an array of physical properties

which make them useful as a skin composition for automotive panels. The NBR acts as a permanent flexibilizing polymer for the PVC. It also acts as a shrinkage control agent, and embossing aid, and improves grain retention. The NBR in  
5 such blends further provides vacuum forming gauge control and exhibits low fog characteristics. NBR is highly compatible with PVC and has the capability of being recycled. It is essential for any polymer which is substituted for NBR to display these essential  
10 characteristics.

US Patent 5,380,785, US patent 5,415,940, US patent 5,504,155, US patent 5,504,160 and US patent 5,616,651 disclose a rubbery polymer which can be blended with PVC to make leathery compositions. These compositions are  
15 particularly useful in manufacturing skins for automotive interior paneling. Skin compositions, which are made utilizing this rubbery polymer, provide a higher level of resistance to heat and ultraviolet light than those made utilizing conventional NBR/PVC blends. The rubbery polymers  
20 of United States Patent 5,380,785 also offer low fog characteristics, low odor, shrinkage control, and grain retention. They also act as an embossing aid and as a permanent flexibilizing modifier. These rubbery polymers also have characteristics which make them useful in  
25 building gasket applications.

US patent 5,380,785 also specifically discloses a rubbery polymer which can be blended with polyvinyl chloride to make leathery compositions having good heat and ultraviolet light resistance, said rubbery polymer being  
30 comprised of repeat units which are comprised of (a) butyl acrylate, or optionally a mixture of butyl acrylate and 2-ethylhexyl acrylate containing up to about 40% 2-ethylhexyl acrylate, (b) at least one member selected from the group

consisting of methyl methacrylate, ethyl methacrylate, methyl acrylate, and ethyl acrylate, (c) acrylonitrile, (d) styrene, (e) a half ester maleate soap, and (f) a crosslinking agent. Polymers of this general type are sold  
5 by the Eliokem Company as Sunigum® rubber.

United States Patent 5,962,591, discloses that blends of certain rubbery polymers with polyolefins can be compatibilized with ethylene alkyl acrylates or ethylene vinyl acetate. These blends can be made so as to be useful  
10 as skins for automotive interior panels and can be made so as to be leathery in nature.

#### Summary of the Invention

The present invention relates to a rubbery polymer  
15 which can be blended with polyvinylchloride (PVC), halogen containing polymers, Polyurethanes, styrenic polymers (polymers which contain styrene such as acrylonitrile butadiene styrene (ABS), acrylonitrile styrene acrylate (ASA), styrene ethylene butadiene styrene (SEBS), etc.),  
20 Polyesters and copolymers ester-ether (COPE), Polyamides, Polycarbonates, as well as Polyolefins via compatibilization techniques to make leathery compositions.

The compositions according to the invention are particularly useful in manufacturing skins for automotive  
25 interior paneling. Skin compositions which are made utilizing this rubbery polymer provide a higher level of resistance to heat and ultraviolet light than those made utilizing conventional NBR/PVC blends. The rubbery polymers of this invention also offer low fog characteristics, low  
30 odor, shrinkage control, and grain retention. They also act as an embossing aid and as a permanent flexibilizing modifier. The rubbery polymers of this invention also have characteristics which made them useful in building gasket

applications.

The present invention more specifically discloses a rubbery polymer having improved properties, which is comprised of repeat units which are comprised of (a) butyl acrylate, or optionally a mixture of butyl acrylate and 2-ethylhexyl acrylate containing up to about 40 percent 2-ethylhexyl acrylate, (b) at least one member selected from the group consisting of methyl methacrylate, ethyl methacrylate, methyl acrylate, and ethyl acrylate, (c) optionally, about 0% to about 40% of an alkoxy ethyl acrylate or an alkoxy ethyl methacrylate, (d) acrylonitrile, (e) styrene, and (f) a crosslinking agent; wherein about 1% to about 10% of a monomer containing reactive cure sites selected from the group consisting of hydroxyl groups, glycidyl groups, carboxylic acid groups, and unsaturated cure sites is incorporated into the rubbery polymer.

The present invention further discloses a process for preparing a rubbery polymer which can be blended with thermoplastics to make leathery compositions having good heat and ultraviolet light resistance, said process comprising the steps of (1) polymerizing (a) butyl acrylate, or optionally a mixture of butyl acrylate and 2-ethylhexyl acrylate containing up to about 40% 2-ethylhexyl acrylate, (b) at least one member selected from the group consisting of methyl methacrylate, ethyl methacrylate, methyl acrylate, and ethyl acrylate, (c) optionally about 0% to about 40% of alkoxy ethyl me(acrylate), (d) acrylonitrile, and (e) a crosslinking agent; wherein about 1% to about 10% of a monomer containing reactive cure sites selected from the group consisting of hydroxyl groups, glycidyl groups, carboxylic acid groups, and unsaturated cure sites is incorporated into the rubbery polymer under

emulsion polymerization conditions to produce a seed polymer containing latex; (2) adding (a) styrene, (b) additional acrylonitrile, and (c) additional crosslinking agent to the seed polymer containing latex under emulsion  
5 polymerization conditions which result in the formation of an emulsion containing the rubbery polymer; (3) recovering the rubbery polymer from the emulsion containing the rubbery polymer.

10 Detailed Description of the Invention

The present invention discloses a rubbery polymer which can be blended with PVC, halogen containing polymers, Polyurethanes, styrenic polymers (polymers which contain styrene such as ABS, ASA, SEBS, etc.), polyesters and  
15 copolymers ester-ether (COPE), polyamides, polycarbonates, as well as polyolefins via compatibilization techniques to make leathery compositions having good heat and ultraviolet light resistance, said rubbery polymer being comprised of repeat units which are comprised of (a) butyl acrylate, or  
20 optionally a mixture of butyl acrylate and 2-ethylhexyl acrylate containing up to about 40% 2-ethylhexyl acrylate, (b) at least one member selected from the group consisting of methyl methacrylate, ethyl methacrylate, methyl acrylate, and ethyl acrylate, (c) optionally, about 0 to  
25 about 40% of alkoxy ethyl me(acrylate), (d) acrylonitrile, (e) styrene, and (f) a crosslinking agent; wherein about 1 to about 10% of a reactive cure site (co)monomer containing hydroxyl groups, glycidyl groups, carboxylic acid groups, or unsaturated cure site is incorporated during emulsion  
30 polymerization onto said rubbery polymer.

Advantageously, such rubbery polymers contain repeat units (chain linkages) which are derived from (a) butyl acrylate, or optionally a mixture of butyl acrylate and 2-

ethylhexyl acrylate containing up to about 40% 2-ethylhexyl acrylate, (b) at least one member selected from the group consisting of methyl methacrylate, ethyl methacrylate, methyl acrylate, and ethyl acrylate, (c) optionally, about  
5 0 to about 40% of alkoxy ethyl me(acrylate), (d) acrylonitrile, (e) styrene, and (f) a crosslinking agent; wherein (g) about 1 to about 10% of a reactive cure site (co)monomer containing hydroxyl groups, glycidyl groups, carboxylic acid groups, or unsaturated cure site is  
10 incorporated during emulsion polymerization onto said rubbery polymer.

These repeat units differ from the monomers that they were derived from in that they contain one less carbon-carbon double bond than is present in the respective  
15 monomer. In other words, a carbon-to-carbon double bond is consumed during the polymerization of the monomer into a repeat unit in the rubbery polymer. Thus, in saying that the rubbery polymer contains various monomers in actuality means that it contains repeat units which are derived from  
20 those monomers.

The rubbery polymers, which are modified in accordance with this invention, will normally contain (a) from about 40 to about 80% by weight butyl acrylate, or optionally a mixture of butyl acrylate and 2-ethylhexyl acrylate  
25 containing up to 40% by weight 2-ethylhexyl acrylate, (b) from about 5 to about 35% by weight methyl methacrylate, ethyl methacrylate, methyl acrylate, or ethyl acrylate, (c) optionally about 0 to about 40% of alkoxy ethyl me(acrylate), (d) from about 4 to about 30% by weight  
30 acrylonitrile, (e) from about 3 to about 25% by weight styrene, (f) from about 0.25 to about 8% by weight of a crosslinking agent wherein (g) from about 0.1 to about 10% by weight of a reactive cure site (co)monomer containing

hydroxyl groups, glycidyl groups, carboxylic acid groups, or unsaturated cure site is incorporated during emulsion polymerization onto said rubbery polymer.

Such rubbery polymers will preferably contain (a) from  
5 about 50 to about 80% by weight butyl acrylate, or  
optionally a mixture of butyl acrylate and 2-ethylhexyl  
acrylate containing up to about 40% 2-ethylhexyl acrylate,  
(b) from about 3 to about 25% by weight of at least one  
member selected from the group consisting of methyl  
10 methacrylate, ethyl methacrylate, methyl acrylate, and  
ethyl acrylate, (c) optionally, about 0 to about 40% of  
alkoxy ethyl me(acrylate), (d) from about 6 to about 30% by  
weight acrylonitrile, (e) from about 5 to about 18% by  
weight styrene, (f) from about 0.5 to about 4% by weight of  
15 a crosslinking agent wherein (g) from about 1 to about 8%  
by weight of a reactive cure site (co)monomer containing  
hydroxyl groups, glycidyl groups, carboxylic acid groups,  
or unsaturated cure site is incorporated during emulsion  
polymerization onto said rubbery polymer.

20 The rubbery polymer will more preferably be comprised  
of repeat units which are derived from (a) from about 55 to  
about 75% by weight butyl acrylate, or optionally a mixture  
of butyl acrylate and 2-ethylhexyl acrylate containing up  
to about 40% 2-ethylhexyl acrylate, (b) from about 5 to  
25 about 20% by weight of at least one member selected from  
the group consisting of methyl methacrylate, ethyl  
methacrylate, methyl acrylate, and ethyl acrylate, (c)  
optionally about 0 to about 40% of alkoxy ethyl  
me(acrylate), (d) from about 10 to about 25% by weight  
30 acrylonitrile, (e) from about 8 to about 14% by weight  
styrene, (f) from about 1 to about 3% by weight of a  
crosslinking agent wherein (g) from about 2 to about 6% by  
weight of a reactive cure site (co)monomer containing

hydroxyl groups, glycidyl groups, carboxylic acid groups, or unsaturated cure site is incorporated during emulsion polymerization onto said rubbery polymer. These percentages are based upon the total weight of the rubbery polymer.

A variety of reactive cure site (co)monomers can be used in carrying out the polymerizations to produce the rubbery polymer. These monomers contain reactive cure sites which are selected from the group consisting of hydroxyl groups, glycidyl groups, carboxyl groups, and unsaturated cure sites.

Some representative examples of monomers containing reactive cure sites which can be utilized include carboxy derivatives such as acrylic or methacrylic acid, maleic acid, fumaric acid and itaconic acid; hydroxy derivatives such as 2-hydroxyethyl (me)acrylate, 2-hydroxypropyl (me)acrylate, 3-hydroxypropyl (me)acrylate, 2-hydroxyethyl crotonate, pentahydroxyethyl (me)acrylate, 2,3,4,5-tetrahydroxy-pentyl (me)acrylate, etc. The particularly preferable monomers are acrylic acid, methacrylic acid, 2-hydroxyethyl acrylate, and hydroxyethyl methacrylate.

Some representative examples of glycidyl derivatives which can be utilized include glycidyl (me)acrylate, allyl glycidyl ether, itaconic acid monoglycidyl ester, butenetricarboxylic acid monoglycidyl ester, butenetricarboxylic acid diglycidyl ester, butenetricarboxylic acid triglycidyl ester, vinyl glycidyl ethers and esters of maleic acid, fumaric acid and crotonic acid, etc. The particularly preferable monomers are glycidyl (me)acrylate and allyl glycidyl ether.

Some representative examples of monomers containing unsaturated cure sites can be utilized include 1,3-butadiene, isoprene, allyl maleate, tetrahydrobenzyl



acrylate, diallyl phthalate, dicyclopentenyl acrylate, dicyclopentenylloxyethyl methacrylate, and the like. When the reactive cure site is an unsaturated cure site, sulfur vulcanisation with or without accelerator or other  
5 vulcanisation agents such as phenolic curatives, benzoquinone derivatives, metal oxides, organic peroxides and bismaleimides can be used to improve the polymer network during processing as described by A.Y. Coran in *Encyclopedia of Polymer Science and Engineering*, 17 (Second  
10 Edition), 666-698. When the reactive cure sites are carboxy derivatives, hydroxy derivatives or glycidyl derivatives, chemical reactions are more preferable to improve compatibilization or polymer network during processing or polymer blending.

15 The present invention further reveals a leathery composition which is useful in automotive applications which is comprised of (1) a thermoplastic such as PVC, halogen containing polymers, Polyurethanes, styrenic polymers (polymers which contain styrene such as ABS, ASA,  
20 SEBS, etc.), polyesters and copolymers ester-ether (COPE), polyamides, polycarbonates, as well as polyolefins via compatibilization techniques, (2) a plasticizer, and (3) a rubbery polymer which is comprised of (a) butyl acrylate, or optionally a mixture of butyl acrylate and 2-ethylhexyl  
25 acrylate containing up to about 40 percent 2-ethylhexyl acrylate, (b) at least one member selected from the group consisting of methyl methacrylate, ethyl methacrylate, methyl acrylate, and ethyl acrylate, (c) optionally, about 0 to about 40% of alkoxy ethyl me(acrylate), (d)  
30 acrylonitrile, (e) styrene, and (f) a crosslinking agent; wherein about 1 to about 10% of a reactive cure site (co)monomer containing hydroxyl groups, glycidyl groups, carboxylic acid groups, or unsaturated cure site is

incorporated during emulsion polymerization onto said rubbery polymer.

These leathery compositions offer an excellent combination of properties for utilization in making skin compounds for panels used in automotive applications. These leathery compositions can be prepared by blending the rubbery polymer into polyvinylchloride (PVC) utilizing standard mixing techniques. It is highly preferred for the improved rubbery polymer of this invention to be in powdered form when blended into PVC to make such leathery compositions.

A wide variety of plasticizers which are compatible with the polyvinyl chloride resins can be employed.

Such leathery compositions typically contain from about 40 to 160 parts by weight of the improved rubbery polymer of this invention, from about 10 to about 50 parts of a plasticizer, and from about 0.1 to about 5 parts by weight of an antidegradant per 100 parts by weight of the polyvinylchloride. It is typically preferred for such leathery compositions to contain from about 60 to about 120 parts by weight of the improved rubbery polymer of this invention, from about 15 to about 40 parts of the plasticizer, and from about 0.5 to 3 parts of an antidegradant (per 100 parts of the PVC). It is typically more preferred for the leathery composition to contain from about 70 to about 90 parts by weight of the improved rubbery polymer of this invention, from about 20 to about 30 parts by weight of the plasticizer, and from about 1 to 2 parts by weight of the antidegradant per 100 parts by weight of the PVC.

Such compositions will also generally contain an acrylonitrile-butadiene-styrene resin (ABS resin).

The leathery composition will typically contain from

about 15 parts to about 80 parts of ABS resin per 100 parts of PVC. The leathery composition will preferably contain from about 25 to about 55 parts per weight of the ABS resin per 100 parts by weight of the PVC. It is generally more  
5 preferred for the leathery composition to contain from about 30 to about 40 parts by weight of the ABS resin per 100 parts by weight of PVC. Various colorants and/or pigments will typically also be added to the composition to attain a desired color.

10 The leathery compositions of this invention are useful in a wide variety of applications. For example, they have been found to be extremely valuable when used in making skins for automotive panels. Such panels are typically comprised of a semi-rigid urethane foam which is supported  
15 by a rigid backing and covered with the leathery composition of this invention. Such skins are made by calendaring the leathery compositions of this invention and then cutting them to the desired size and shape. Such skins for automotive applications which are made with the  
20 leathery compositions of this invention offer outstanding heat and ultraviolet light stability. These are highly desirable characteristics which can help to prevent the skin of automotive panels from cracking during the normal life of the vehicle.

25 The improved rubbery polymers of this invention can also be blended with other halogen containing polymers (in addition to PVC), styrenic polymers (polymers which contain styrene, such as acrylonitrile-styrene-acrylate (ASA) polymers, ABS, SEBS polymers, etc.), polyesters and  
30 copolyester-ether, polycarbonates, polyamides, polyurethanes, polyolefins to produce compositions which exhibit good heat and ultraviolet light resistance. Such polymeric compositions can be used in manufacturing a wide

variety of useful articles, such as profiles, moldings, sheeting, flooring, wall coverings, hose, cables, and footwear. Virtually any type of polyamide (nylon) can be utilized in preparing such blends. These nylons are  
5 generally prepared by reacting diamines with dicarboxylic acids. The diamines and dicarboxylic acids which are utilized in preparing such nylons will generally contain from about 2 to about 12 carbon atoms. However, nylons which can be utilized in such blends can also be prepared  
10 by addition polymerization. Some representative examples of nylons which can be used include nylon-6,6, nylon-6, nylon-7, nylon-8, nylon-9, nylon-10, nylon-11, nylon-12 and nylon-6,12. Some representative examples of polyolefins which can be used include low density polyethylene, linear  
15 low density polyethylene, high density polyethylene, polypropylene, metallocene catalyzed polyolefins, and modified polyolefins, such as ethylene vinyl acetate (EVA), ethylene-alkyl (Me)acrylate or terpolymers of ethylene, alkyl (Me)acrylate and acrylic acid.

20 The present invention further discloses a process for preparing a rubbery polymer which can be blended with PVC, halogen containing polymers, polyurethanes, styrenic polymers (polymers which contain styrene such as ABS, ASA, SEBS, etc.), polyesters and copolymers ester-ether (COPE),  
25 polyamides, polycarbonates, as well as polyolefins via compatibilization techniques to make leathery compositions having good heat and ultraviolet light resistance, said process comprising the steps of (1) polymerizing (a) butyl acrylate, or optionally a mixture of butyl acrylate and 2-  
30 ethylhexyl acrylate containing up to about 40% 2-ethylhexyl acrylate, (b) at least one member selected from the group consisting of methyl methacrylate, ethyl methacrylate, methyl acrylate, and ethyl acrylate, (c) optionally, about

0 to about 40% of alkoxy ethyl me(acrylate), (d) acrylonitrile, and (e) a crosslinking agent; wherein about 1 to about 10% of a reactive cure site (co)monomer containing hydroxyl groups, glycidyl groups, carboxylic acid groups, or unsaturated cure site is incorporated under  
5 emulsion polymerization conditions to produce a seed polymer containing latex; (2) adding (a) styrene, (b) additional acrylonitrile, and (c) additional crosslinking agent to the seed polymer containing latex under emulsion  
10 polymerization conditions which result in the formation of an emulsion containing the rubbery polymer; (3) recovering the rubbery polymer from the emulsion containing the rubbery polymer.

The rubbery polymers, which are modified in accordance  
15 with the process of present invention, are synthesized in an aqueous reaction mixture by utilizing a free radical polymerization technique. The reaction mixture utilized in this polymerization technique is comprised of water, the appropriate monomers, a suitable free radical initiator, a  
20 crosslinking agent, and a soap.

A wide variety of soaps (emulsifiers) can be utilized in carrying out the polymerization to produce the rubbery polymer. Some representative examples of soaps which can be utilized include the half ester maleate soap, and/or the  
25 metal salt of an alkyl sulfonate or the metal salt of an alkyl sulfate.

The half ester maleate soap utilized in the polymerization is prepared by reacting maleic anhydride with a fatty alcohol containing from about 10 to about 24  
30 carbon atoms. It is typically preferred to utilize a fatty alcohol which contains from about 12 to about 16 carbon atoms. One mole of the maleic anhydride is reacted with one mole of the fatty alcohol in producing the half ester

maleate soap. This reaction is typically conducted at a temperature that is within the range of about 50°C to about 80°C. Sodium hydroxide or potassium hydroxide is then added to make the half ester maleate soap.

5        Some representative examples of sulfonate and sulfate surfactants which can be used include sodium toluene-xylene sulfonate, sodium toluene sulfonate, sodium cumene sulfonate, sodium decyldiphenyl ether sulfonate, sodium dodecylbenzenesulfonate, sodium dodecyldiphenylether  
10 sulfonate, sodium 1-octane sulfonate, sodium tetradecane sulfonate, sodium pentadecane sulfonate, sodium heptadecane sulfonate. Metal salts of alkylbenzene sulfonates are a highly preferred class of sulfonate surfactant. The metal will generally be sodium or potassium.

15        The sulfonate surfactant can be a mixture of (mono)dialkylate ether disulfonates. The advantage of the disulfonate structure is that it contains two ionic charges per molecule instead of one as in the case with conventional alkyl sulfonate surfactants.

20        The sulfate surfactants, which are useful in the practice of this invention, include metal salts of alkylsulfates having the structural formula  $\text{ROSO}_3\text{X}$  and metal salts of alkylethersulfates having the structural formula  $\text{RO}(\text{CH}_2\text{CH}_2\text{O})_n\text{SO}_3\text{X}$ , wherein R represents an alkyl group and  
25 wherein X represents sodium or potassium. Sodium lauryl sulfate, sodium ethanolamine lauryl sulfate, triethanolamine lauryl sulfate are representative examples of commercially available sulfate surfactants.

30        The reaction mixture utilized in this polymerization technique will normally contain from about 10 to about 80% by weight monomers, based upon the total weight of the reaction mixture. The reaction mixture will preferably contain from about 20 to about 70% by weight monomers and

will more preferably contain from about 40 to about 50% by weight monomers.

The free radical emulsion polymerizations utilized in synthesizing the rubbery polymer are typically conducted at  
5 a temperature which is within the range of about 10°C to about 95°C. In most cases, the polymerization temperature utilized will vary between about 20°C and about 80°C. The polymerization is carried out as a two-step batch process. In the first step, a seed polymer containing latex is  
10 synthesized.

This is done by polymerizing (a) butyl acrylate, or optionally a mixture of butyl acrylate and 2-ethylhexyl acrylate containing up to about 40% 2-ethylhexyl acrylate, (b) at least one member selected from the group consisting  
15 of methyl methacrylate, ethyl methacrylate, methyl acrylate, and ethyl acrylate, (c) optionally, about 0 to about 40% of alkoxy ethyl me(acrylate), (d) acrylonitrile, (e) a crosslinking agent wherein (f) about 1 to about 10% of a reactive cure site (co)monomer containing hydroxyl  
20 groups, glycidyl groups, carboxylic acid groups, or unsaturated cure site is incorporated during emulsion polymerization onto said rubbery polymer.

The seed polymer containing latex is typically prepared by the polymerization of a monomer mixture which contains  
25 about 40 to about 90% by weight butyl acrylate, or optionally, a mixture of butyl acrylate and 2-ethylhexyl acrylate containing up to about 40% 2-ethylhexyl acrylate, from about 5 to about 35% by weight methyl methacrylate, ethyl methacrylate, methyl acrylate, or ethyl acrylate,  
30 from about 2 to about 30% by weight acrylonitrile, and from about 0.25 to 6% by weight of the crosslinking agent wherein from about 0.1 to about 10% by weight of a (co)monomer containing hydroxyl groups, glycidyl groups,

carboxylic acid groups, or unsaturated cure site is incorporated during emulsion polymerization onto said rubbery polymer.

It is typically preferred for the monomeric component  
5 utilized in the first step to include about 50 to about 85%  
by weight butyl acrylate, or optionally a mixture of butyl  
acrylate and 2-ethylhexyl acrylate containing up to about  
40% 2-ethylhexyl acrylate, from about 5 to about 30% by  
weight ethyl acrylate, ethyl methacrylate, methyl acrylate,  
10 or methyl methacrylate, from about 4 to about 28% by weight  
acrylonitrile, and from about 0.5 to about 4% by weight of  
the crosslinking agent wherein (g) from about 0.1 to about  
10% by weight of a (co)monomer containing hydroxyl groups,  
glycidyl groups, carboxylic acid groups, or unsaturated  
15 cure site is incorporated during emulsion polymerization  
onto said rubbery polymer.

It is generally more preferred for the monomer charge  
composition used in synthesizing the seed polymer latex to  
contain from about 60% to about 80% by weight butyl  
20 acrylate, or optionally a mixture of butyl acrylate and 2-  
ethylhexyl acrylate containing up to about 40% 2-ethylhexyl  
acrylate, from about 5 to about 25% by weight methyl  
methacrylate, ethyl methacrylate, methyl acrylate, or ethyl  
acrylate, from about 5 to about 25% by weight  
25 acrylonitrile, and from about 1 to about 3% by weight  
crosslinking agent wherein (g) from about 0.1 to about 10%  
by weight of a (co)monomer containing hydroxyl groups,  
glycidyl groups, carboxylic acid groups, or unsaturated  
cure site is incorporated during emulsion polymerization  
30 onto said rubbery polymer.

After the seed polymer latex has been prepared, styrene  
monomer, additional acrylonitrile monomer, and additional  
crosslinking agent is added to the seed polymer containing



latex. As a general rule, from about 4 parts by weight to about 30 parts by weight of styrene, from about 1 part by weight to about 20 parts by weight of additional acrylonitrile, and from about 0.01 to 2 parts by weight of the crosslinking agent will be added to the seed polymer per 100 parts dry weight of the seed polymer. In this second stage of the polymerization, it is preferred to add from about 6 parts by weight to about 22 parts by weight of styrene, from about 3 parts by weight to about 12 parts by weight of acrylonitrile, and from about 0.05 parts by weight to 1 part by weight of the crosslinking agent. It is typically more preferred for from about 10 parts by weight to about 17 parts by weight of styrene, from about 4 parts by weight to about 8 parts by weight of acrylonitrile, and from about 0.1 parts by weight to about 0.5 parts by weight of the crosslinking agent to be added to the seed polymer latex to initiate the second phase of the polymerization.

A wide variety of crosslinking agents can be utilized in carrying out the polymerizations to produce the rubbery polymer. Some representative examples of crosslinking agents which can be utilized include difunctional acrylates, difunctional methacrylates, trifunctional acrylates, trifunctional methacrylates, and divinylbenzene. 1,4-butanediol dimethacrylate has proven to be particularly useful as the crosslinking agent.

The rubbery polymer can be made by the two-step batch, semi-continuous, or continuous emulsion polymerization process. In most cases, the polymerization will be continued until a high monomer conversion has been reached. At this point, the rubbery polymer made by the two-step polymerization process is recovered from the emulsion (latex) after the optional deodorizing step. This can be

accomplished by utilizing standard coagulation techniques. For instance, coagulation can be accomplished by the addition of salts, acids, or both to the latex.

After the rubbery polymer is recovered by coagulation,  
5 it can be washed to further reduce odors. This can be accomplished by simply pouring or spraying water on the rubbery polymer. The rubbery polymer can also be washed by putting it in a water bath which will further reduce odor. After being washed, the rubbery polymer is generally dried.  
10 It is sometimes advantageous to convert the rubbery polymer into a powder to facilitate its usage. In this case, it will be beneficial to add a partitioning agent to the rubbery polymer. Some representative examples of partitioning agents which can be employed include calcium  
15 carbonate, emulsion polyvinyl chloride, and silica. Calcium carbonate is a highly desirable partitioning agent which can be utilized in such applications.

This invention is illustrated by the following examples that are merely for the purpose of illustration  
20 and are not to be regarded as limiting the scope of the invention or the manner in which it can be practiced. Unless specifically indicated otherwise, parts and percentages are given by weight.

25                   Example 1 (comparative example)

In this experiment, a rubbery polymer was made in a 10 litre stainless steel reactor. The reactor was equipped with an axially flow turbine agitator which was operated at 450 rpm (revolutions per minute).

30           The reactor was charged with 6348.68 grams of water, 72.8 grams of a half ester maleate soap (made with a C<sub>16</sub> fatty alcohol), 2.73 grams of sodium dodecylbenzenesulfonate, 31.2 grams of a 50 percent aqueous

potassium hydroxide solution, 5.2 grams of sodium pyrophosphate, 1837.68 grams of n-butylacrylate, 218.4 grams of acrylonitrile, 109.2 grams of methylmethacrylate, 44.2 grams of 1,4-butanediol dimethacrylate, 2.08 grams of t-dodecylmercaptan, 1.56 grams of triethanol amine, and 6.5 grams of potassium persulfate were initially charged into the reactor. A temperature of about 35°C was maintained during the first stage of the polymerization. When a solids content of about 20% was reached the reaction temperature was increased to about 60°C and a temperature of about 60°C was maintained throughout the polymerization until the total solids content of about 25% was achieved. This first stage of polymerization was carried out for a period of about 2.5 hours. This first stage polymerization resulted in the production of seed polymer latex which was used in the second step of the polymerization.

In the second step of the polymerization, 124.8 grams of acrylonitrile, 242 grams of styrene, 4.68 grams of divinylbenzene, and 0.78 grams of t-dodecylmercaptan were charged into the reactor containing the seed polymer latex. The polymerization proceeded until a solids content of about 30% was reached.

The latex made was subsequently coagulated and a dry rubber was recovered.

25

#### Example 2

In this experiment, a rubbery polymer was synthesized in a 10 litres reactor utilizing the technique of this invention. In the procedure employed 6348.68 grams of water, 72.8 grams of hexadecylmonomaleate, 9.1 grams of a 30% solution of sodium dodecylbenzene sulfonate, 31.2 grams of a 50% aqueous potassium hydroxide solution, 5.2 grams of sodium pyrophosphate, 8.4 grams of acrylonitrile, 4.2 grams

of methyl methacrylate, 71.4 grams of n-butyl acrylate, 39 grams of glycidyl methacrylate, 26 grams of 1,4-butanediol dimethacrylate, 2.08 grams of t-dodecylmercaptan, 1.56 grams of triethanol amine, and 6.5 grams of potassium persulfate were initially charged into the reactor. A temperature of about 35°C was maintained during the first stage of the polymerization. When a solids content of about 20% was reached the reaction temperature was increased to about 60°C and 124.8 grams of additional acrylonitrile, 242 grams of styrene, 4.88 grams of divinylbenzene, and 0.78 grams of t-dodecylmercaptan were charged into the reactor.

After the polymerization was completed, the latex made was coagulated and a rubber was recovered.

15

#### Example 3

The procedure used in Example 2 was repeated in this experiment except that 44.2 grams (instead of 26 grams) of 1,4-butanediol dimethacrylate was charged into the reactor.

20

#### Example 4

The procedure used in Example 2 was repeated in this experiment, except that 44.2 grams (instead of 26 grams) of 1,4-butanediol dimethacrylate and 130 grams of dicyclopentenylxyethyl methacrylate (instead of 39 grams of glycidyl methacrylate ) were charged into the reactor.

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Antioxydants, such as Wingstay L<sup>®</sup> or Wingstay K<sup>®</sup>, in emulsion form or in dispersion form can be used to stabilize the rubbery polymer during drying and storage.

30

The latex made was subsequently coagulated and a dry rubber was recovered.

Example 5

The procedure used in Example 4 was repeated in this experiment, except that 130 grams of diallyl phthalate was  
5 used to replace the dicyclopentenylloxyethyl methacrylate.

Examples 6-9

In these series of experiments, leathery compositions were made by blending the rubbery polymers made in Examples  
10 1 and 3 or other rubbery polymers (Chemigum®) into PVC. In the procedure used 40 parts of the rubbery polymers was blended into 100 parts of the PVC. The blends made also included 80 parts of DOP and 3 parts of Ba/Zn. The blends were made by mixing the components in a mill at 180°C for 6  
15 minutes and then pressing them into samples at 180°C. The samples made were then tested to determine their physical properties.

The physical properties of the samples made are reported in Table I. The blend made in Example 6 contained  
20 Eliokem Chemigum® P83, the blend of Example 7 contained Eliokem Chemigum® P35, the blend of Example 8 contained the rubber composition of Example 1, and the blend of Example 9 contained the rubber composition of Example 3.

As it can be seen in Table I, all the rubbery polymers  
25 made in Examples 1 and 3 could be made into leathery compositions, which had good physical properties compared to the Chemigum® nitrile rubber.

TABLE I

Examples	Shore A Hardness	Tensile Strength	Elongation	Modulus		Compression set 22h at 70°C
				50% MPa	100% MPa	
Example 6	64	13MPa	500%	3.3	5.8	58.2%
Example 7	64	9.7MPa	417%	2.8	4.9	51.4%
Example 8	65	11.8MPa	352%	2.2	4.5	56.9%
Example 9	65	10.9MPa	326%	2.3	4.5	56.4%

Examples 10-13

5            In these series of experiments, leathery compositions were made by blending the rubbery polymers made in Examples 1, 4 and 5 into PVC. The procedure of Examples 6-9 was repeated except 100 parts of the rubbery polymers was blended into 100 parts of the PVC.

10           The physical properties of the samples made are reported in Table II. The blend made in Example 10 contained the rubber composition of Example 1, the blend of Example 11 contained rubber composition of Example 4, the blend of Example 12 contained the rubber composition of  
15   Example 5, and the blend of Example 13 contained the rubber composition of Example 4 and 10 parts of Lotader<sup>®</sup> AX 8900<sup>®</sup> per 100 parts of the rubbery polymer as a crosslinking agent.

TABLE II

Examples	10	11	12	13
Hardness Shore A	56	56	57	57
Tensile Strength (MPa)	11.5	10	9.8	10.3
Elongation at break %	282	239	205	232
Modulus at 50% (MPa)	1.8	2.0	2.0	2.2
Modulus at 100% (MPa)	3.5	3.8	3.9	4.2
Tear Strength (kN/m)	23	19.2	19.4	20.6
Compression set 22hrs at 70°C	54.6	48.6	45	42

As it can be seen from Table II, the compression set  
5 behaviour of the blends made with the rubber composition  
polymer of this invention was better than was that of the  
control.

Examples 14-18

10 In these series of experiments, rubbery polymer was  
blended into metallocene catalyzed polyethylene. In the  
procedure, 60 parts of the rubbery polymer was blended at a  
temperature of 180°C with 40 parts of Engage<sup>®</sup> 8100 in a  
Haake Rheocord 90 operated at 60 rotations per minute over  
15 a period of 30 minutes. Blends were pressed into samples  
at 180°C. The samples were then tested to determine their  
physical properties.

The physical properties of the samples made are  
reported in Table III. The blend made in Example 14  
20 contained rubber composition of Example 1. Example 15 was  
a compatibilized blend of the rubber composition of Example  
1 and 10 parts of Lotader<sup>®</sup> 8900 percent parts of the rubber  
composition polymer. For comparative purposes, a second  
blend was made with the rubber composition of Example 3  
25 without including the compatibilizing polymer in Example

16, or with 10 parts of Lotader® 8900 per 100 parts of the rubber composition polymer in Example 17 or with 10 parts of Elvax® 360 per 100 parts of the rubber composition in Example 18.

5

TABLE III

Examples	14	15	16	17	18
Shore A Hardness	60	63	60	63	62
Tensile Strength (MPa)	4.3	6.6	4.1	10. 4	4.8
Elongation at break (%)	700	500	475	490	750
Modulus at 50% (MPa)	1.7	1.9	1.6	1.9	1.8
Modulus at 100% (MPa)	2.6	2.8	2.5	3	2.7
Tear Strength (kN/m)	26	25	24	43	27

As it can be seen from Table III, the physical properties of the blends made with the rubber composition polymer of this invention are better than those of the control that did not contain any monomers containing glycidyl functional groups.

10

Examples 19-25

15 In this series of experiments, the rubbery polymer was blended into high density polyethylene HDPE having a melt flow index (MFI) of about 4. In the procedure utilized 70 parts of the rubbery polymer was blended at a temperature of 180°C with 30 parts of KS10100 high density polyethylene (HDPE) from Dow Plastics in a Haake Rheocord 90 operated at 20 60 rpm over a period of 30 minutes. The blends were pressed into samples at 180°C. The samples were then tested to determine their physical properties.

The physical properties of the samples made are



reported in Table IV. The blend made in Example 19 contained the rubber composition of Example 1. Example 20 was a compatibilized a blend of the rubber composition of Examples 1 and 10 parts of Elvax<sup>®</sup> 360, while Example 21 was a compatibilized blend of the rubber composition of Example 1 and 10 parts of Lotader<sup>®</sup> AX 8900. For comparative purpose, a second blend was made with the rubber composition of Example 2 without including the compatibilizing polymer in Example 22 or with 10 parts of Elvax<sup>®</sup> 360 per 100 parts of the rubber composition in Example 23. Otherwise, Example 24 was the blend of Example 16 including 10 parts of Elvax<sup>®</sup> 670 and Example 25 was the blend of Example 16 including 10 parts of Lotader<sup>®</sup> AX8900.

TABLE IV

Examples	19	20	21	22	23	24	25
Tensile at break (MPa)	5.1	5.2	9.5	5.6	9.8	9.3	12.6
Elongation at break %	74	147	270	71	203	192	282
Modulus 50% (MPa)	5.4	5.1	6.4	5.2	6.6	6.5	6.3
Modulus 100% (MPa)	-	-	-	-	7.9	7.8	7.8
Tear strength kN/m	37	34	54	28	50	44	54

As it can be seen from Table IV, physical properties of compatibilized blends made with the rubber composition polymer of this invention are better than was the control that did not contain any monomers with glycidyl functional groups.

Examples 26-29

In these series of experiments, the same procedure as utilized in Examples 19-25 was repeated, except 40 parts of

the rubbery polymer was blended with 60 parts of HDPE KS 10100 from Dow Plastics and 10 parts of the compatibilizing polymer per 100 parts of the rubber composition polymer. Examples 26 and 27 were compatibilized blends of the rubber composition of Examples 1 and 2, respectively, and 10 parts of Lotader<sup>®</sup> AX 8900 per cent parts of the rubber composition polymer. Examples 28 and 29 were compatibilized blends of the rubber composition of Examples 1 and 2, respectively, and 10 parts of Elvax<sup>®</sup> 360 per cent parts of the rubber composition polymer.

The physical properties of the samples made are reported in Table V.

TABLE V

Examples	26	27	28	29
Tensile at break (MPa)	8.7	12.6	10.4	12.7
Elongation at break %	287	367	51	184
Modulus 50% (MPa)	-	12.1	9.7	12.7
Modulus 100% (MPa)	-	12	-	12.6
Tear strength kN/m	113	112	69	80

15

As it can be seen in Table V, physical properties of the compatibilized blends made with the rubber composition polymer of this invention are better than those of the control for both types of compatibilizing polymers (Lotader<sup>®</sup> AX 8900 as well as Elvax<sup>®</sup> 360).

20

While certain representative embodiments and details have been shown for the purpose of illustrating the subject invention, it will be apparent to those skilled in this art that various changes and modifications can be made therein without departing from the scope of the subject invention.

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